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Effect of gamma irradiation on physicochemical properties of Karanda (*Carissa carandas*) fruit at different stages of maturity

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Abstract
The total acidity and titrable acidity among all the maturity stages were found highest in dried karanda fruit (19.61± 0.05% and 3.18±0.06% respectively), pH (4.57±0.04) in ripe fruit, TSS(39.26±0.05 B^0) in dried fruit. The color values based on the hunter colour flex found that the lightness 'L' values in three maturity stages showed significant difference i.e 71.86±1.23 in raw, followed by ripe fruits in dried karanda fruits. The chromacity 'a' was found highest in ripe fresh (28.49±0.03) followed by raw (18.57±0.42) and dried fruit (9.49±0.02). The 'b' value chromacity was found highest in ripe fruits (86.42±0.05) followed by raw and dried fruits. The total acidity (20.18±0.03%) and titrable acidity (3.92±0.01%) and TSS (35.67±0.05 B^0) was found highest in dried irradiated fruit at 1.00 kGy. The ripe blanched fruits recorded highest pH (4.28±0.02) value. The colour values i.e 'L' value (28.09±0.03) in blanched dried fruit, 'a' value (28.87±0.07) in ripe blanched fruit and 'b' value (86.42±0.03) in ripe irradiated fruit at 0.25 kGy were found with highest values.

Keywords: Gamma irradiation on physicochemical, *Carissa carandas*

Introduction

Tropical fruits, which are at present underutilized, have an important role to play in satisfying the demand for nutritious, delicately flavoured and attractive natural foods of high therapeutic value. Today, consumers are becoming increasingly conscious of the health and nutritional aspects of their food basket. The tendency is to avoid chemicals and synthetic foods and preference for nutrition through natural resources. The underutilized fruits like aonla, bael, jamun, karonda, passion fruit, phalsa, pomegranate, pumpkin, tamarind, wood apple etc. are the main sources of livelihood for the poor and play an important role in overcoming the problem of malnutrition (Gajanana *et al.*, 2010) [9]. They are in general accepted as being rich in vitamins, minerals and dietary fibre and therefore, are an essential ingredient of a healthy diet.

Fruits and vegetables are rich source of natural antioxidants such as vitamin C, tocopherol, phenolics and b-carotene which contribute to their antioxidant or free radical or scavenging effects. Amongst these, phenolics serve as powerful antioxidants by virtue of the hydrogen-donating properties of their phenolic hydroxyl groups, as well as by donating electrons to stop free radical chain reactions emerging from oxidative stress (John and Shahidi, 2010).

Foods of plant origin contain many bioactive compounds in addition to conventionally identified nutrients such as proteins, energy, vitamins and specific minerals. More than 900 different phytochemicals have been identified as components of food and there may be more than 100 in just one vegetable (Akindahunsi & Salawu 2005) [1]. Epidemiological studies have demonstrated that people eating vegetarian diets have a reduced risk of heart diseases and obesity (Bagchi & Puri, 1998) [3] due to antioxidants and phenolic compounds.

In Ayurveda, the unripe fruits were used as an anthelmintic, astringent, appetizer, antipyretic, antidiabetic, in biliary disorders, stomach disorders, rheumatism and diseases of brain (Morton, 1987; Iyer and Dubhash, 2006) [14, 11]. It is useful in treatment of diarrhea, anorexia and intermittent fevers. Fruits have also been studied for its analgesic, anti-inflammatory and lipase-1 activities (Balakrishnan and Bhaskar, 2009) [4]. It is used by tribal healers of Western Ghat region of Karnataka as hepato protective and anti-hyperglycemic. However, no scientific data is available to validate the folklore claim (Kirtikar and Basu, 2003; Christophe, 2006) [13, 7].

A systematic approach understanding the variation in physicochemical, nutritional, total phenolics, flavonoids and total antioxidant in karanda fruit on minimal, primary and secondary processing would helps in standardization of an appropriate processing strategy for the development of the consumers' preferred antioxidant rich products in the global market.

Material and Methods

Karanda fruits were procured from ARI, Rajendranagar. All chemicals used in the investigation were of analytical grade. Chemicals, glassware's were utilized from the laboratory of Post Graduate and Research Centre PJTSAU, Rajendranagar, Hyderabad.

Physicochemical properties

1. Titrable acidity-TA (AOAC, 2000)

Titratable acidity is a measure of the buffering capacity of the fruit and is generally expressed as a percent of the predominant organic acid. Titrable Acidity was determined by AOAC, 2000 method.

10 g of homogenized sample was weighed in a 100ml volumetric flask. Then made up to 100ml with distilled water. The contents were then filtered through Whatman No 1 filter paper. An aliquot of 10ml was taken in a conical flask, to which 2-3 drops of Phenolphthalein indicator was added and Titrated against 0.1N NaOH till light pink color appears. The end point was recorded and titrable acidity was estimated in terms of percent citric acid.

Calculation: Factor for acidity = one ml of N/10 NaOH = 0.0064 g of citric acid

% Titrable acidity = Titre value x 0.0064 x 100

2. Total soluble solids -TSS (AOAC, 2000)

TSS is commonly expressed as °Brix and is typically measured using a hand-held refractometer. Refractrometer is designed to measure the refractive index of a solution. The °Brix scale is based on a sucrose and water solution. However, since most samples contain substances other than sugar- such as salts, minerals and proteins. The Brix percentage represents the total concentration of all soluble solids in the sample.

Calculation: The percentage of TSS = °Brix value

3. pH (AOAC, 2000)

In general, fruits are acidic with pH ranging from 2.5 to 4.5. The most common acids in fruits are citric acid, malic acid, and tartaric acid. ELICO L1 127 Digital pH meter was used to measure the pH content of the samples.

The buffer tablets of pH 4.0 and pH 7.0 were dissolved in 100 ml distilled water each. The pH meter was calibrated with these buffer solutions before measuring the pH of samples. The electrode was taken out from the buffer, washed with distilled water and wiped out with tissue paper. The pH electrode was dipped in the fruit drink sample and pH of the sample was noted from the display.

4. Color (AOAC, 2000)

Color flex/ hunter is used to measure the color of the samples. The Hunter L, a, b color scale is more visually uniform than the XYZ color scale. The Hunter L, a, b color space is organized in a cube form. The maximum for L is 100, which would be a perfect reflecting diffuser. The maximum for L would be zero, which would be black. The 'a' and 'b' axes have no specific numerical units. Positive 'a' is red and negative 'a' is green. Positive 'b' is yellow and negative 'b' is blue. The hunter lab/color flex software in computer was calibrated using black and white round plates. Then the sample color values were noted down L, a, b values.

Results and Discussion

1. Titrable acidity

The titrable acidity of the fresh karanda fruits decreased significantly as the maturity progrssed viz, dried (1.92±0.08%), ripe (2.65±0.08%) and raw (3.18±0.06%) karanda fruits. The trend was found similar in blanched and irradiated fruits. In the dried fruits blanching and irradiation had no significant impact on titrable acidity. Whereas, in ripe fruits titrable acidity increased in irradiated fruits compare to fresh ripe fruits, but there was no statistical significance among the irradiated ripe fruits at 0.25, 0.5 and 1.00 kGy irradiation dose.

In raw karanda fruits significantly highest (3.92±0.01%) TA values were found at 1.00 kGy dose and there was no significant difference in blanched and irradiated fruit at 0.25 and 0.5 dosage. The acidity of the fruits is used to indicate the flavor characteristics. A high level of acidity commonly found in unripe fruits leads to sour taste in fruits. Over-ripe fruits have very low levels of fruit acid and the ripe fruits are sourer than unripe fruits (Table 1).

TA was expressed as percentage of citric acid in karonda fruit. There was no significant difference in TA of karonda fruit among the three maturity stages. Usually organic acids decline during ripening as they respired or converted to sugars. There was no changes in TA were found as maturity progressed. (Wills *et al.*, 2007) [16].

2. Total soluble solids

Total soluble solids indicate sugar in the pulp. The riper the fruit more amount of sugar in fruits. The TSS values present in the table showed that there was a significant increase in TSS content of unprocessed fruit as the maturity was progressed (Raw 12.23±0.0, ripe 19.69±0.41 and in dried fruit 39.26±0.05).

It was found that there was no significant difference in the brix of processed raw, ripe and unprocessed fruits. However, in dried fruit there was a significant decrease in TSS from unprocessed to processed dried fruits and among the different treatments there was no significant difference (Table 1).

Parmar and Kaushal (1982) [15] reported 10.2 per cent of TSS in *Cordia dichotoma* fruit. TSS, acidity and ascorbic acid content in *lassiyade* was in the range of 6-7 per cent, 0.08-0.1 per cent and 32-48 mg% respectively in the analyzed samples.

3. pH

The pH of the karanda fruit at raw stage was reported as 3.43±0.02 and increased as fruit matured to ripe stage 4.57±0.04 and declined at dried stage (3.35±0.10). In the processed raw fruit there was no significant difference between fresh except in irradiated fruit at 1.00kGy (3.33±0.01) where pH is lower than in other treatments.

In ripe fruit the pH was found to be highest in unprocessed (4.57±0.04) followed by blanched (4.28±0.02) and irradiated at 0.5kGy (4.24±0.01) than at 0.25kGy (4.16±0.02) and it was lowest in irradiated fruit at 1.00kGy (2.91±3.30).

In dried fruit pH was found to be highest in irradiated fruit at 0.5kGy and 1.00kGy (3.56±0.11, 3.56±0.12 respectively)

followed by blanched and irradiated at 0.25kGy (3.49±0.01, 3.48±0.01 respectively) and it was least in unprocessed dried fruit (3.35±0.10) and the change in pH was not significant (Table 1).
Gaikwad and co-workers 2005 reported an average moisture, total soluble solids, titrable acidity content and pH to be 72.36 per cent, 19º Brix, 0.35 per cent and 2.72, respectively in karanda.

4. Colour

The colour was estimated using hunter colour flex, where 'L' indicates the highest , 'a' indicates chromacity on a green (-) to red (+) axis and ' b' chromacity on blue (-) to yellow (+) axis. There was significant difference ($P \leq 0.05$) among the three maturity stages in the pulp colour of raw, ripe and dried fruits.
The lightness 'L' values in three maturity stages showed significant difference i.e 71.86±1.23 in raw, followed by ripe fruits 68.19±0.21 and 27.50±0.03 in dried karanda unprocessed fruits. The similar trend was also observed in different processing treatments i.e blanching and irradiation at 0.25kGy, 0.5kGy and 1.00kGy in three maturity stages, where the highest 'L' value was observed in raw stage followed by ripe and dried stage.
The blanching had significant impact on L values which was found highest in three maturity stages (raw: 77.58±0.96, ripe: 69.07±0.01 and dried: 28.09±0.03) and there was no significant difference during irradiation at 0.25kGy (raw: 72.43±0.12, ripe: 68.53±0.12 and dried 26.58±0.05), irradiation at 0.5kGy (raw:73.12±0.13, ripe:67.36±0.14 and dried: 26.54±0.04) and irradiation at 1.00kGy (raw: 72.65±0.09, ripe: 66.10±1.2 and dried: 26.36±0.04) when compared with unprocessed karanda fruit at different maturity stages.
The chromacity "a" (green (-) to red (+) axis) of three maturity stages of karanda showed significantly higher values in ripe fresh (28.49±0.03) followed by raw (18.57±0.42) and dried fruit (9.49±0.02). In blanched and irradiated fruit at 0.25kGy, 0.5kGy and 1.00kGy the ripe fruits recorded highest 'a' vales followed by raw and dried fruits.
In raw fruits blanching showed significant difference with lower values (18.42±0.32) than from irradiation treatment. There was no significant difference in 'a' value in irradiated fruit at 0.25kGy (18.79±0.03), 0.5kGy (18.67±0.01), 1.00kGy (18.82±0.02) and fresh raw fruit (18.57±0.42).
In ripe fruit no significant difference was recorded in fresh (28.49±0.03), blanched (28.87±0.07) and irradiated fruit at 0.25kGy (28.75±0.02) and 0.5kGy (28.62±0.02), whereas irradiated fruit at 1.00kGy showed significant reduction in 'a' value (28.29±0.07).
In dried fruit, blanching (10.02±0.07) and irradiation at 0.5kGy (10.01±0.09) showed significantly higher values from fresh (9.49±0.02), irradiated at 0.25kGy (9.48±0.03) and 1.00kGy (9.48±0.02).
The 'b' value chromacity on a blue (-) to yellow (+) axis in unprocessed, three maturity stages reported highest in ripe fruits (86.42±0.05) followed by raw and dried fruits. The similar trend was observed in blanched and irradiated treatments.
In raw fruits, the processing treatments yielded lower 'b' value compared to unprocessed fruits (85.36±1.3) and in blanched (83.46±0.60) and irradiated fruits at 0.25kGy (83.59±0.02), 0.5kGy (83.75±0.02) and 1.00KGy (83.35±0.03) had no significant difference in 'b' value.
In ripe and dried fruits no significant difference was observed in fresh as well as all processing treatments, except dried irradiated fruit at 0.5kGy (10.10±0.01) (Table 1).
The changes in peel colour during fruit maturation can be explained by the synthesis of the dark purple colour pigment and marked the decrease of chlorophyll as maturation progressed Chanasith *et al.*, (2017) [6] found similar values in karnda based yogurt ice-cream sorbets and juices. Chai and Ding (2013) [5] found that the karanda pulp harvested at red stage had highest L* values (68.14) and C* values (18.08) among the three maturity stages. The pulp colour of karanda showed significant differences at different maturity stages.. In contrast, the pulp of fruit at purple stage showed lowest L*, C* and h° values. This showed that the pulp colour changed from yellow to red as maturity progressed. (Jamaludin *et al.*, 2011) [12].

Conclusion

On the basis of results obtained from the present investigation, the following conclusions are drawn: The total acidity and titrable acidity among all the maturity stages were found highest in dried karanda fruit, pH in ripe fruit, TSS in dried fruit. The color values based on the hunter colour flex found that the lightness 'L' values in three maturity stages showed significant difference in raw, followed by ripe fruits in dried karanda fruits. The chromacity 'a' was found highest in ripe fresh followed by raw and dried fruit. The 'b' value chromacity was found highest in ripe fruits followed by raw and dried fruits.

Table 1: Physico chemical quality of karanda fruit under different treatments (per 100g)

Parameters	Stage of ripening	Unprocessed	Blanching	Irradiation			SE Values	CD
				0.25 kGy	0.5 kGy	1.0 kGy		
Total Acidity (%)	Raw	10.25±0.01 ^{c2}	9.94±0.06 ^{c3}	10.61±0.34 ^{c1}	9.95±0.10 ^{c3}	10.19±0.12 ^{c2}	3.06	0.107
	Ripe	10.96±0.01 ^{b1}	10.14±0.02 ^{b3}	10.94±0.01 ^{b1}	10.16±0.01 ^{b3}	10.64±0.03 ^{b2}		
	Dried	19.61±0.05 ^{a3}	19.92±0.17 ^{a2}	19.32±0.10 ^{a4}	18.74±0.12 ^{a5}	20.18±0.03 ^{a1}		
SE value	0.13							
CD	0.064							
Titrable Acidity (%)	Raw	1.92±0.08 ^{c1}	1.95±0.05 ^{c1}	1.97±0.01 ^{c1}	1.98±0.04 ^{c1}	2.01±0.04 ^{c1}	0.542	0.041
	Ripe	2.65±0.08 ^{b2}	2.17±0.02 ^{b3}	2.80±0.01 ^{b1}	2.83±0.04 ^{b1}	2.76±0.05 ^{b1}		
	Dried	3.18±0.06 ^{a3}	3.84±0.03 ^{a2}	3.80±0.02 ^{a2}	3.83±0.04 ^{a2}	3.92±0.01 ^{a1}		
SE value	0.0180							
CD value	0.024							
TSS (^{0}Brix)	Raw	12.23±0.06 ^{c1}	12.9±0.10 ^{c1}	9.2±0.02 ^{c1}	10.13±0.15 ^{c1}	13.1±0.1 ^{b1}	7.27	2.238
	Ripe	19.69±0.41 ^{b1}	20.0±1.07 ^{b1}	19.18±6.22 ^{b1}	18.72±0.91 ^{b1}	20.51±0.54 ^{b1}		
	Dried	39.26±0.05 ^{a1}	35.17±0.02 ^{a2}	35.15±0.03 ^{a2}	35.22±0.07 ^{a2}	35.67±0.05 ^{a2}		
SE value	0.51							
CD	1.343							

PH	Raw	3.43±0.02 ^{b1}	3.39±0.01 ^{c1}	3.38±0.02 ^{c1}	3.44±0.02 ^{c1}	3.33±0.01 ^{b2}	0.28	0.047
	Ripe	4.57±0.04 ^{a1}	4.28±0.02 ^{a2}	4.16±0.01 ^{a3}	4.24±0.02 ^{a2}	2.91±2.30 ^{c4}		
	Dried	3.35±0.10 ^{c3}	3.49±0.01 ^{b2}	3.48±0.01 ^{b2}	3.56±0.11 ^{b1}	3.56±0.12 ^{a1}		
SE value	0.018							
CD	0.028							

Colour

Parameters		Stage of ripening	Unprocessed	Blanching	Irradiation			SE Values	CD
					0.25 kGy	0.5 kGy	1.0 kGy		
Colour	L	Raw	71.86±1.23 ^{a3}	77.58±0.96 ^{a1}	72.43±0.12 ^{a2}	73.12±0.13 ^{a2}	72.65±0.09 ^{a2}	14.64	0.503
		Ripe	68.19±0.21 ^{b2}	69.07±0.01 ^{b1}	68.53±0.12 ^{b2}	67.36±0.14 ^{b3}	6 6.10±1.24 ^{c4}		
		Dried	27.50±0.03 ^{c2}	28.09±0.03 ^{c1}	26.58±0.05 ^{c3}	26.54±0.04 ^{c3}	26.36±0.04 ^{b3}		
		SE value	0.549						
		CD	0.302						
	a	Raw	18.57±0.42 ^{b1}	18.42±0.32 ^{b2}	18.79±0.03 ^{b1}	18.67±0.01 ^{b1}	18.82±0.02 ^{b1}	5.460	0.151
		Ripe	28.49±0.03 ^{a1}	28.87±0.07 ^{a1}	28.75±0.02 ^{a1}	28.62±0.25 ^{a1}	28.29±0.07 ^{a2}		
		Dried	9.49±0.02 ^{c2}	10.02±0.07 ^{c1}	9.48±0.03 ^{c2}	10.01±0.09 ^{c1}	9.48±0.02 ^{c2}		
		SE value	0.054						
		CD	0.091						
	b	Raw	85.36±1.3 ^{b1}	83.46±0.60 ^{b2}	83.59±0.02 $^{b 2}$	83.75±0.02 ^{b2}	83.35±0.03 ^{b2}	24.021	0.360
		Ripe	86.42±0.05 ^{a1}	86.06±0.05 ^{a1}	86.42±0.03 ^{a1}	86.39±0.01 ^{a1}	86.21±0.04 ^{a1}		
		Dried	13.9±0.01 ^{c1}	13.68±0.05 ^{c1}	13.84±0.03 ^{c1}	10.10±0.10 ^{c2}	13.81±0.03 ^{c1}		
SE value	SE value 0.292								
	CD 0.216								

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